

Web-enabled supply chain management: Key antecedents and performance impacts

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ABSTRACT

Despite increased interest and growing investments in web-based supply chain management (SCM) applications, firms face numerous challenges in successfully web-enabling their SCM activities. In this research, we focus on two main objectives – (i) to understand the key antecedents that affect the web-enablement of SCM activities; (ii) to document the performance impacts of web-enabled SCM efforts. Based on a large-scale, questionnaire survey of North American organizations, we assessed the influence of six factors namely – supplier synergy, information intensity, managerial IT knowledge, interoperable IT infrastructure, perceived IT returns on investments (ROI) and formal governance mechanisms – on the extent of web-enabled SCM. Our results revealed a strong positive influence of supplier synergy, information intensity, managerial IT knowledge, inter-operability and formal governance mechanisms on the extent of web-enabled SCM. We also found a negative association between relative cost–benefit perceptions and the extent of web-enabled SCM. Further, we also found strong positive association between extent of web-enabled SCM and the benefits realized from SCM efforts. We discuss the implications of our results for research and practice.

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1. Introduction

The emergence of the Internet as a ubiquitous, cost-effective business medium has fundamentally changed the way companies transact, communicate, acquire and utilize resources, as well as build and sustain competitive edge. The rapidly changing competitive landscape, characterized by intense competition, globalization, and blurred industry boundaries is driving businesses to be more efficient than ever before, increasing the pressure to cut costs as well as create new innovations. Information technology is a tool that facilitates information management and enhances information flow, thereby making the supply chain more robust and resilient without undermining its efficiency (Pereira, 2009). Consequently, in response to the changing business dynamics, businesses are using the Internet to streamline their supply and distribution chains, reengineer business processes, enrich customer interactions and provide cost-effective and value-added services.

Throughout the 1980s and 1990s, most companies focused on improving internal efficiency and internal business processes. However, the competitive dynamics of the current environment, coupled with advances in web technologies are forcing compa-

nies to look beyond corporate boundaries into the realm of supply chain networks to create distinct value propositions and added efficiencies. In fact, there is a gradual shift in focus from traditional linear value chain to digital web-enabled supply networks (Straub, Rai, & Klein, 2004). Companies such as Dell, Nokia, Wal-Mart, and Rockwell Automation, have used web technologies to create greater integration with suppliers, reduce distribution costs, enhance superior supplier relationships, and enhance their overall business performance. The success of such initiatives has inspired several companies to use the web to streamline their supply chain management activities. Estimates by market research firms show that US firms are increasingly investing in digital web-enabled supply chain initiatives (Supply Chain Advisor, 2003).

Despite the growing recognition about the importance of web-enabling supply chain management and the increased investments in web-enabled SCM efforts, firms are facing numerous challenges in transforming their SCM activities. In fact, many firms are faced with disappointments and dissatisfaction with the outcomes in their web-enabled SCM efforts. AMR Research (www.amrresearch.com) reports that about 65% of large companies have implemented web-enabled supply-chain systems, but less than a fifth of those find that the systems making a significant difference to their businesses (Bachelder, 2003). A survey of 200 companies by Booz Allen and Hamilton found 45% of firms to be dissatisfied with the results from their web-enabled SCM efforts

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(Rossi, 2003). Another survey by Forrester reported more than half (54%) of their respondents to be unhappy with their SCM applications (Supply Chain Advisor, 2003). There is also anecdotal evidence of firms such as Nike and K-Mart that have suffered due to snafus in their SCM systems (Taylor, 2003). Apart from financial losses, supply chain glitches and technology implementation failures could also lead to an erosion of shareholder value (Hendricks & Singhal, 2003). Hence, it is not surprising that a recent survey identified business interruption (related to supply chain failure) as among the top three risks facing global firms (Aon, 2009).

Given the increased investments in web-enabled SCM efforts and the growing challenges to effective implementation of web-enabled SCM systems, there are still many unanswered questions about the transformation of SCM activities using the web. Notably, we know only little about the key factors that promote or dissuade the extent of web-enablement of SCM activities. Further, there is relatively limited empirical documentation of the performance impacts of web-enabled SCM applications (Rai, Patnayakuni, & Patnayakuni, 2006; Subramani, 2004). As web-based SCM applications require considerable investments in terms of money, effort and time, it is important to examine if these systems lead to any positive performance improvements, and investigate the key factors that affect their usage. Our overall research objectives are to understand the key factors that affect the web enablement of SCM activities, and to document the ultimate performance impacts of web-enabled SCM efforts. The research questions addressed in this study are:

1. What are the key antecedents that affect the extent of web-enabled SCM?
2. Does web-enabled SCM create any significant performance improvements for firms engaging in such initiatives?

2. Theoretical background and research model

2.1. Web-enabled SCM

Web-enabled SCM refers to the extent of usage of web technologies in supply chain management activities. It captures the degree to which a firm has deployed and integrated web-based technologies in different supply chain activities. Web enablement reflects the efforts of firms to leverage the potential of web technologies in their SCM activities and related strategies. Despite making significant investments in web technologies, considerable diversity exists in how well firms have been able to assimilate these technologies and leverage their potential in SCM. Firms that do not effectively do so risk a drop in their competitiveness, apart from a failure to realize any value from their significant investments. The process of web-enabled SCM rarely unfolds in systematic and predictable fashion and is often fraught with several challenges.

Our conceptualization of web-enabled SCM parallels the concepts of 'technology usage' and 'technology assimilation' that is prevalent in MIS research. The level of technology usage has widely been accepted as an important indicator of IT success in organizations. Several researchers have sought to empirically understand the business value of technology and have documented the criticality of the level of technology usage (Devaraj & Kohli, 2003). Explaining the importance of IT usage, Devaraj and Kohli argue that "the actual usage of technology may be the key in assessing the relationship between implementing information technologies and benefits or payoffs resulting from them" (p. 286).

In this study, we build upon prior research on IT usage and extend it to the context of usage of web technologies in SCM activities. We view web-enabled SCM as the extent to which web technologies and applications are being used in different SCM

activities such as procurement, logistics, warehousing, supplier selection and demand management, etc. Hence, the extent of web-enablement reflects the degree of transformation of SCM function using web technologies and applications.

2.2. Theory development and hypotheses

A firm's critical resources may span firm boundaries and the potential strategic advantage could primarily emanate from inter-organizational relationships. Dyer and Singh (1998) propose four primary sources of relational rents: (i) synergistic and complementary capabilities among partners, (ii) investments in relational assets, (iii) knowledge capabilities and inter-firm knowledge sharing, and (iv) use of effective governance mechanisms. In developing our research model (Fig. 1), we specifically chose constructs that were relevant to the SCM and MIS literature, while ensuring coverage of all the four sources of relational rents.

Synergistic and complementary partner capabilities: Resource-based view and the notion of dynamic capabilities suggest that firm-specific resources and the organizational capabilities are key to enhancing business performance. Synergistic and complementary capabilities are major motivations for supply chain relationships as they help create value that cannot be generated independently. While traditional technologies such as dedicated networks and EDI have been major enablers for creating and sustaining supply chain relationships, web-based technologies have further accelerated this trend. Greater opportunities for exploiting synergies between the partner firms are likely to accelerate technology usage in SCM.

Relational IT investments: Investments in relation-specific assets help improve inter-firm transactional efficiency, reduce operational bottlenecks, and decrease total value chain costs (Klein, Rai, & Straub, 2007; Patnayakuni, Rai, & Seth, 2006). Specific investments made towards implementing SCM systems among partners have value-creating properties. For instance, Cisco has implemented a supplier connection application (CSC), through which suppliers have access to Cisco's enterprise resource planning (ERP) order fulfillment systems and inventory databases so that they can respond to customer requests in real time (Kraemer & Dedrick, 2002). In the context of web-enabled SCM, investments in inter-operable IT infrastructure (Gosain, Malhotra, & El Sawy, 2004–2005), and perceived returns on investments (ROI) from such IT systems are likely to influence the extent of web-enablement.

Knowledge capital: Knowledge-based view of the firm suggests knowledge to be at the core of economic rent generation. Knowledge capital in partner firms and the extent of knowledge sharing among supply chain partners create value for firms in the partnership. For effective assimilation and diffusion of IT within and among firm networks, managerial IT knowledge has often been cited as a critical resource (Armstrong & Sambamurthy, 1999). Knowledge exchange and sharing within and organization and across supply chain provides significant relationship gains (Im & Rai, 2008). IT knowledge among SCM executives, and supply chain related functional knowledge among IT executives would facilitate web-enabled SCM, and pave the way for relational rents.

Governance: Governance mechanisms play a critical role in ensuring effective management of relationship, and in realizing the basic objectives of the partnership (Wathne & Heide, 2004). Effective governance mechanisms for implementing IT systems include formal planning and use of cross-functional teams for designing and implementing these systems (Johnson, Klassen, Leenders, & Awaysheh, 2007).

In summary, drawing upon Dyer and Singh's (1998) work, our model consists of four sets of antecedents that potentially influence web-enabled SCM: (i) supplier synergy, (ii) investments in relational assets – interoperable IT infrastructure and IT ROI, (iii)

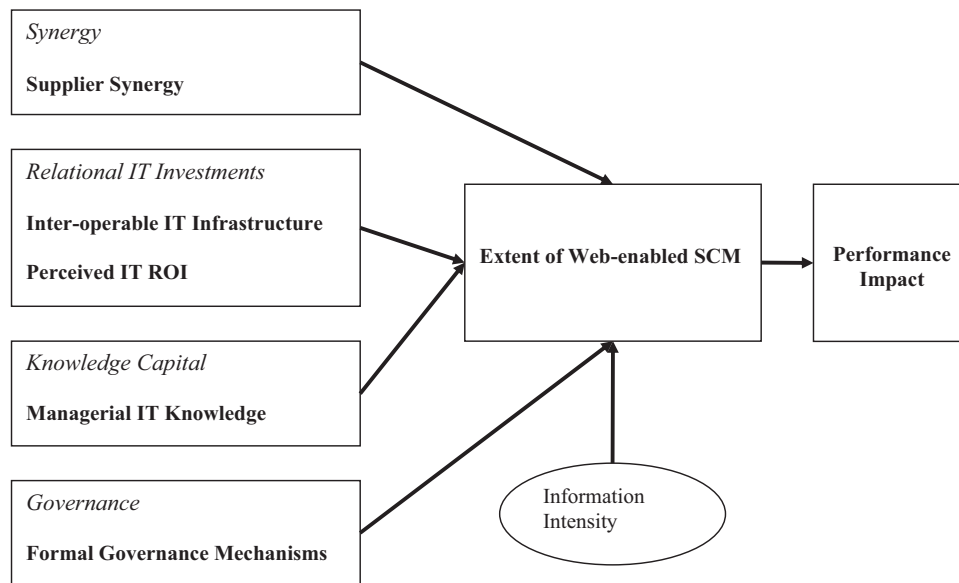


Fig. 1. Research model.

knowledge capital – managerial IT knowledge, and (iv) formal governance mechanisms for designing and deploying web-enabled SCM systems. In addition to these factors, we also include information intensity in supply chain as it has been identified as a critical variable affecting technology diffusion in inter-firm networks. All these factors (Table 1) are hypothesized to affect the web-enablement of SCM activities, which in turn affects performance.

2.3. Supplier synergy

Most buyer–supplier relationships in a supply chain are characterized by certain degree of inter-dependencies between the partners. These dependencies have often been characterized by terms such as “supplier power”, “bargaining power”, etc. in literature. Supplier power has often been considered to be one of the key forces affecting an organization’s strategies (Porter & Miller, 1985). Young, Carr, and Rainer (1999) emphasized that trading partner relationships and the balance of power are critical issues to consider when firm participates in electronic linkages along the supply chain. Researchers have also pointed out that healthy supply chain relationships require mutual trust and faith between the partners (Doney & Cannon, 1997; Handfield & Bechtel, 2001). If a firm is able to synergize its relationship with suppliers, it can potentially reduce its cost of products and thereby become more competitive. The electronic markets hypothesis, put forth by Malone, Yates, and Benjamin (1987) suggests that IT reduces coordination costs due to its abilities to diminish communication and information processing costs, facilitate description of complex

products, and reduce asset-specific investments in a supply chain relationship. Since web technologies offer a cost-effective way to integrate with suppliers, one could expect strong supplier synergies to be associated with higher levels of web-enabled SCM activities. Our belief is also strengthened by prior empirical studies on EDI and IOS that suggest tighter association between supplier synergies and higher technology usage (Premkumar & Ramamurthy, 1995; Premkumar, Ramamurthy, & Crum, 1997). Hill and Scudder (2002) found firms in food industry tend to use EDI more when they seek greater coordination with their suppliers in their supply chain. In the context of e-procurement, synergies with suppliers have been found to play a vital role in firm’s adoption and usage of web technologies for online procurement (Deeter-Schmelz, Bizzari, Graham, & Howdysshell, 2001). IT use has been found to promote co-operative behavior in buyer–supplier relationships (Grover, Teng, & Fiedler, 2002). Interdependence and synergies with supply chain partners have been found to be vital in B2B supply chain relationships (Crook, Giunipero, Reus, Handfield, & Williams, 2008; Kim, Narayan, & Kim, 2005–2006; Zhao, Huo, Flynn, & Yeung, 2008) as well. Therefore,

H1. The greater the synergy with suppliers, the greater will be the extent of web-enablement of SCM activities.

2.4. Information intensity

According to the information processing theory (Galbraith, 1977), organizations are viewed as complex systems who constantly acquire, exchange, process and utilize information with the

Table 1
Key factors and literature support.

Key factors in research model	Sources
Supplier synergy	Chatfield and Yetton (2000), Deeter-Schmelz et al. (2001), Grover et al. (2002), Hart and Saunders (1998), Kim et al. (2005–2006), Premkumar et al. (1997) and Zhao et al. (2008).
Inter-operable IT infrastructure	Angeles (2009), Gosain et al. (2004–2005), Liu et al. (2005), Premkumar and Ramamurthy (1995), Rai et al. (2006) and Ramamurthy and Premkumar (1995).
Perceived IT ROI	Chatterjee et al. (2002), Chwelos et al. (2001), Klein et al. (2007), Kuan and Chau (2001), Premkumar et al. (1994), Ramamurthy and Premkumar (1995) and Teo et al. (1997–1998).
Managerial IT knowledge	Boynton et al. (1994), Corbett and Blackburn (1999) and Teo and King (1997).
Formal governance mechanisms	Byrd and Davidson (2003), Doll (1985), Johnson et al. (2007), Patnayakuni et al. (2006), Raghunathan and Raghunathan (1994), Sabherwal (1999) and Teo and Ranganathan (2004).
Information intensity	Porter and Miller (1985), Sabherwal and Vijayasarathy (1994), Kearns and Lederer (2003) and Teo et al. (1997–1998).

elements of the external environment. In the SCM context, this theory calls for effective exchange of information among a firm and its supply chain partners. The information processing requirements are likely to vary across industries, based on the extent of information flows in the value chain and in the primary products and services (Porter & Miller, 1985). The degree to which information is present in the product or service of a business reflects the level of information intensity of that product or service (Thong, 1999). Information intensity reflects the extent of potential interaction and information-exchange across buyer-supplier cohorts along the supply chain. In an information intensive environment, the need for information sharing across a supply chain in a cost-effective manner greatly augments the need for using web technologies and applications.

Porter and Miller (1985) emphasized that the greater the information intensity of products/services offered by the firm, the greater the likelihood that IT will play an important role in the firm. Hence, firms in more information-intensive sectors are more likely to adopt and utilize technology than those in less information intensive sectors. Palmer and Griffith (1998) suggest a strong association between information intensity and a firm's Internet-related initiatives. Sabherwal and Vijayasathy (1994) found information intensity to significantly influence a firm's use of telecommunication links with suppliers and customers. The extent of information exchanged and the nature of information exchanged in inter-firm transactions have been found to influence the technology usage in buyer-supplier relationships (Carr & Smeltzer, 2002). More recently, Kearns and Lederer (2003) showed information intensity in a firm's environment to be a key determinant of its ability to use technology for strategic purposes. Firms operating in information intensive environments are likely to have higher information processing requirements that are likely to significantly impact their technology usage. Web technology enables greater information processing and relatively lower costs, and therefore information intensive environments are likely to foster higher levels of web-enabled SCM activities. Based on this discussion, we propose the following:

H2. The greater the information intensity in a firm's supply chain environment, the greater will be the extent of web-enablement of SCM activities.

2.5. Managerial IT knowledge

Managerial IT knowledge refers to the union of IT-related and business-related knowledge possessed and exchanged among IT executives and functional managers. It is a conjunction of tacit knowledge of functional SCM managers regarding IT and the business related knowledge possessed by IT executives. The necessity of functional management knowledge and appreciation of IT for ensuring the success of IT assimilation is well understood and documented (Crook et al., 2008). In order to achieve an effective alignment of IT and business objectives, it is imperative for the IT executives to have a good knowledge of the supply chain domain in which the firm operates.

Boynton, Zmud, and Jacobs (1994) suggest that only an amalgamation of IT and business knowledge could lead to effective technology diffusion. Armstrong and Sambamurthy (1999) found evidence of a positive impact of senior management's IT knowledge on the extent of IT assimilation. Applying a resource-based view of firms, Mata, Fuerst, and Barney (1995) identified managerial IT knowledge as a critical IT capability for successfully deploying systems for gaining strategic benefits. For effective web-enablement of SCM activities, it is important that management have a good understanding of both web technologies as well as the potential strategic impact of web technologies on the SCM function.

H3. The greater the extent of managerial IT knowledge, the greater will be the extent of web-enablement of SCM activities.

2.6. Inter-operable IT infrastructure

Innovation diffusion literature has often found the compatibility of innovation as being an essential condition for the adoption and diffusion of innovation by an organization (Tornatzky & Klein, 1982). The IT literature has extended the notion of compatibility by emphasizing that IT must have a good fit with the tasks it supports in order for technology to be used to enhance performance (Goodhue & Thompson, 1995). Further, to exploit the integrated capabilities of IT, new systems and technologies must be compatible with existing organizational technologies. Ramamurthy and Premkumar (1995), in their study of EDI diffusion, had used the term compatibility to refer to interoperability. Their study emphasized that the integration of EDI with other IT applications as well as the interoperability of IT systems internally within the firm and externally with trading partners are crucial factors in deriving benefits from EDI adoption. Similarly, in a study of B2B e-commerce and EDI, Kaefer and Bendoly (2004) identified interoperability of EDI technologies among trading partners to be important. In a similar vein, Ferguson and Hill (1989) suggested that the lack of standards and incompatibility of technologies as one of the major inhibitors to the wider use of EDI among trading partners. Recently, Nurmilaakso (2008) found firms with interoperable IT systems, including ERP and standardized data to utilize more e-business systems in their supply chain integration.

In this paper, inter-operability refers to the ability of e-commerce applications to work smoothly with the firm's existing systems as well as with business partners' systems. It reflects on the extent to which new systems can be seamlessly integrated with existing technologies in an organization. Inter-operability is a measure of technological compatibility. Inter-operability provides standardized, modular and structured technological setup that offers the flexibility to scale supply chain operations (Gosain et al., 2004–2005). Without interoperability of systems, the full benefits of e-commerce in terms of enhancing efficiency and reducing cost are difficult to achieve (Crook et al., 2008). In fact, the lack of IT integration has been cited as the chief reason why many B2B projects fail to deliver the benefits users expect (Meehan, 2002). Using a case study, Liu, Zhang, and Hu (2005) highlight the importance of interoperability in the context of supply chain management systems. Rai et al. (2006) found that integrated and inter-operable IT infrastructure enabled firms to achieve superior supply chain process integration that ultimately led to significant and sustained performance gains. In a similar vein, Angeles (2009) found that IT infrastructure integration is essential to achieve desired outcomes. While an inter-operable IT infrastructure could greatly facilitate integration of supply chain processes within the enterprise as well as pave the way for greater inter-firm connectivity, incompatibility between current systems and new web applications could hinder their proliferation and usage in the SCM function. Hence, it follows that:

H4. The greater the inter-operability of the web-based SCM applications with existing systems, the greater will be the extent of web-enablement of SCM activities.

2.7. Perceived IT ROI

Researchers have frequently debated on the returns from technology investments. Given that the use of web technologies in the SCM function is relatively new and that it normally transcends organizational boundaries, problems in assessing its benefits arise especially when most firms are interested in "hard" data such as

revenue growth or profitability rather than “soft” data such as impact on customer satisfaction or supplier effectiveness. Further, Meehan (2002) reported that an inability to measure the performance of B2B applications designed to connect multiple trading partners is a big factor in the low success rate of B2B. Hence for web-based applications to be adopted and assimilated, firms must perceive that the benefits outweighs the costs of adoption and implementation, i.e., the perceived IT return-on investment (ROI) must be positive. Chatterjee, Grewal, and Sambamurthy (2002) found that a well-developed strategic investment rationale leads to greater assimilation of the web technologies. This notion is analogous to the concept of relative advantage found in IT adoption and diffusion literature. Specifically, previous research has found that perceived relative advantage is one of the best predictors of an innovation’s rate of adoption and that a positive relationship exists between relative advantage and adoption behaviors (Teo, Tan, & Buk, 1997–1998).

In EDI research, studies have found relative advantage to be a key determinant of adoption (Chwelos, Benbasat, & Dexter, 2001) as well as internal diffusion of EDI (Premkumar, Ramamurthy, & Nilakanta, 1994; Ramamurthy & Premkumar, 1995). Scala and McGrath (1993) examined the advantages and disadvantages of EDI from an industry perspective and found that a key issue is the perception of costs of implementing EDI versus savings from EDI usage. Kuan and Chau (2001) examined 575 small firms in Hong Kong and found that perceived direct benefits facilitated EDI adoption. In an empirical study of the European automotive industry, Buxmann, von Ahsen, Diaz, and Wolf (2004) found that unquantified benefits rather than high costs inhibit the web-enablement of SCM activities. Since greater perceived benefits and greater perceived ROI would potentially aid a firm’s usage of web technologies in SCM, it follows that:

H5. The greater the perceived costs with respect to the benefits of web technologies in SCM, the lesser will be the extent of web-enablement of SCM activities.

2.8. Formal governance mechanisms

In our research, formal governance mechanisms include using plans and cross-functional teams for carrying out the web-enablement efforts in SCM activities. The importance of formal IT planning in the strategic use of information resources has been commonly emphasized in the literature. For example, in a study of 36 firms, Sabherwal (1999) found that 16 of 18 successful users had formal IT plans. Raghunathan and Raghunathan (1994) found empirical support for linking IT planning and IT success. In a similar vein, Doll (1985) reported that firms with successful information systems were three times more likely to have and use formal plans for systems development.

The implementation of e-commerce initiatives is a strategic business decision not just a technology decision (Goldberg & Sifonis, 1998). As such, effective implementation of e-commerce initiatives often requires using formal plans and formal teams to provide direction and focus. In addition, the presence of a formal plan and formal team can enable the firm to respond to new developments and opportunities, minimize duplicated efforts by different business units, minimize incompatible systems and wasted resources, and establish priorities for the effort (Gottschalk, 1999). Saban (2001) emphasized the importance of strategic preparedness (i.e., formulating an integrated e-commerce plan) to reap maximum benefits from e-commerce investments.

Pant, Sim, and Hsu (2001) emphasized the importance of formal planning for web-based information systems. In an empirical study of B2B e-commerce, Teo and Ranganathan (2004) found that of the 52.8% firms who had adopted B2B e-commerce, two-thirds

had a formal plan and/or formal team dedicated to deploying e-commerce. In an empirical survey of 225 firms, Byrd and Davidson (2003) found a positive relationship between IT plan utilization and IT impact on the supply chain. Patnayakuni et al. (2006) found the use of formal mechanisms to enhance information flow integration in supply chains. Johnson et al. (2007) also reported higher level of e-business technology usage when firms used cross-functional purchasing teams. Therefore, we can expect that the use of formal governance mechanisms will lead to greater web-enablement of SCM activities. It follows that:

H6. The greater the use of formal governance mechanisms, the greater will be the extent of web-enablement of SCM activities.

2.9. Performance impacts of web-enabled SCM

There has been considerable research on the performance impacts of IT. Although the empirical results have been mixed, there is a clear recognition regarding the difficulty in directly linking IT usage to business performance. Researchers have recommended assessing the impacts of technology by examining the specific benefits realized by implementing a system (Devaraj & Kohli, 2003; Lee, 2001). In line with these suggestions, we assess performance impacts of web systems in SCM function through the actual benefits realized by implementing web applications.

Research on IOS and EDI has found significant performance improvements (Chatfield & Yetton, 2000; Lee, Clark, & Tam, 1999). Teo, Tan, Wei, and Woo (1995) examined the benefits of Tradenet, a well known EDI system in Singapore that links various parties involved in trade. Mukhopadhyay, Kekre, and Kalathur (1995) used data from Chrysler Corporation to examine the benefits of EDI and documented the annual savings. Williamson, Harrison, and Jordan (2004) analyzed the development of inter-organizational information systems within SCM, and their impact on the effectiveness of the supply chain. They found that the Internet has improved inter-organizational information systems capability and is being adopted as a routine platform for information systems development within supply chain management.

There is also some evidence on the performance impacts of web-enabled SCM applications. For example, Subramaniam and Shaw (2002) examined the value and impact of web-enabled B2B e-commerce using a case study of e-procurement. They found that the value of web-based procurement is most determined by the process characteristics, organization of business units, and the “extended enterprise.” Subramani (2004) examined the use of supply chain management systems by 131 suppliers of a large retailer and empirically documented the association between usage and benefits. Examining data from 260 manufacturing companies, Zhu and Kraemer (2002) showed greater usage of web technologies to be significantly and positively associated with supply chain efficiency. Further, Frohlich and Westbrook (2002) and Frohlich (2002) found that higher levels of performance were associated with higher levels of web-enabled SCM activities. More recently, Rai et al. (2006) provided evidence for increased performance following web-enabled SCM chain initiatives. They argued that IT investment in SCM creates higher-order process capabilities, which lead to increased performance. Increased use of digital technologies in supply chain enhances operational and strategic coordination, which ultimately results in better performance (Sanders, 2008). Devaraj, Krajewski, and Wei (2007) found that e-Business technologies improve supplier integration, which ultimately results in superior performance. Therefore, one could expect that firms that web-enable their SCM activities to a greater extent are likely to reap greater benefits than those who did not.

H7. The greater the extent of web-enablement of SCM activities, the greater will be the benefits realized from it.

3. Method

3.1. Survey administration

We used the ACR directory of top computer executives in North America and Toronto Stock Exchange's Listed Company Directory to select a pool of 1200 organizations that had more than 500 employees and at least 20 IT personnel. Pure-play Internet firms (dot com companies) were not included in our sample as our intention was to examine the web-enablement of SCM activities in relatively well-established settings. The survey package was mailed to the senior most IT executive, often the CIO of the organization. The choice of key informants was guided by several considerations. From our pilot study and field interviews, the appropriate key informants were determined to be senior IT executives who are responsible for IT and e-business initiatives in the organization. This is consistent with Seidler (1974), who recommended that the informants chosen should be in a position to generalize "about patterns of relevant behavior, after summarizing either observed or expected organizational relations" (p. 817). The survey package included a personalized cover letter that explained the purpose of the study, survey instrument and a business reply envelope. Two additional mailings were made to the executives – first, a reminder letter after 2 weeks, and a second reminder letter was mailed four weeks later. These resulted in 249 responses, with an effective response rate of 20.75%. We had asked our respondents to indicate if they had deployed web technologies in their SCM function. This was important as our research goals pertained to understanding the experience of firms who had deployed web technologies in SCM. Of the 249 firms, 176 answered in affirmative and consistent with our research goals, only these responses were included in our final analysis.

3.2. Sample profile

Some salient characteristics of the firms responding to our survey are provided in Table 2. As can be seen, manufacturing companies made up 27.84% of our sample, followed by service and utilities firms (19.32%), and finance-related and other firms making up 14.77% each. The firms in our sample were fairly distributed across different industry groups in manufacturing and service sectors. In terms of annual revenue, about two-thirds had annual revenues over \$50 million. From Table 2, one could also note that most of our respondents were senior IT executives holding titles such as CIOs, Senior Vice Presidents and Directors. Overall, the characteristics of respondents in our sample profile shows that the data were obtained from a fairly heterogeneous group and provides good confidence in the data obtained from the survey.

3.3. Non-response bias

We took several measures to assess non-response bias. Based on the suggestions by Armstrong and Overton (1977), we compared the early and late respondents over a number of parameters. The fundamental rationale for this comparison is that non-respondents tend to closely resemble the later-respondents. The *t*-tests testing for differences between the late and early respondents across the key research constructs did not indicate any significant differences. We performed chi-square tests to assess presence of any industry bias among firms in our sample. No significant differences were found. We also assessed if the revenue levels differed between late and early respondents, and no significant differences were detected. Further, we tested the sample bias by examining the final set of 176 firms used in our analysis (those who had deployed web applications in SCM) with the other 73 firms who had responded back to our survey, but had indicated that they had not deployed

Table 2
Sample profile.

Sample	Frequency	%
<i>Industry</i>		
Manufacturing/Engineering	49	27.84
Finance/Banking/Insurance	26	14.77
Medical/Healthcare related	5	2.84
Services and Utilities	34	19.32
Transportation and Logistics	12	6.82
Retailing and Wholesale	24	13.64
Others	26	14.77
Total	176	100.0
<i>Annual revenues</i>		
Less than 1 million	1	0.6
1.1–5 million	4	2.3
5.1–10 million	13	7.4
10.1–50 million	39	22.3
50–100 million	56	31.8
>100 million	62	35.2
NA	1	0.6
Total	176	100.0
<i>Titles of respondents</i>		
CIO/CTO/VP – IS/Senior VP-IS	63	35.80
Senior Director/Director – IS	28	15.91
General Manager/Manager – IS, VP-IS and Asst Director – IS	35	19.89
VP/Director – e-Business	6	3.41
General Manager/Manager – e-Business	14	7.95
Project Manager/Project Leader – e-Business	5	2.84
IS Project Manager/Executive Manager/Others	6	3.41
NA	19	10.80
Total	176	100.00

any web-based SCM systems. The chi-square tests based on revenue levels indicate a possible bias (chi-square = 39.75, $p < 0.1$) between the web-system deployers and others. The implication is that the respondent firms that had deployed web-based SCM applications were fairly large firms, with higher levels of revenue as compared to the other group. This needs to be kept in mind in interpreting and applying the results of our study.

3.4. Measures and pilot tests

Measures for the research constructs used in our study were developed by borrowing and adapting established measures from prior literature. Most of the items were measured using a 7-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. The antecedents in our research model comprise six constructs. Supplier synergy was assessed using four items that examined a firm's dependence on its suppliers and the reciprocal dependence of suppliers on the firm. These measures were adapted from Premkumar and Ramamurthy (1995). Information intensity was assessed using three items derived from Grover (1993). Four items used to capture Managerial IT Knowledge were adapted from Boynton et al. (1994). These items focused on the extent of IT knowledge of functional executives and business-related knowledge of IT executives. Inter-operability was assessed using three items derived from Premkumar and Ramamurthy (1995) and Ramamurthy and Premkumar (1995). These items assessed the extent to which the new web systems for SCM were compatible with the firm's existing data resources, networking infrastructure and information systems.

Consistent with our conceptualization, web-enablement of SCM activities was measured using five items that tapped the extent to which firms had deployed and used web technologies in five key SCM activities – supplier selection (proposals, quotations, bidding, etc.), purchase order processing, procurement (distribution,

warehousing and logistics), invoicing and payment processing, and demand management and procurement analysis. The initial set of these items were derived from a review of SCM literature (Elmuti, 2002; Grover et al., 2002; Simchi-levi, Kaminsky, & Simchi-levi, 2008; Tan, 2002; Wisner & Tan, 2000), and were subsequently refined during pilot tests. We used six items to capture the performance impacts of web-enablement of SCM activities. These items were adapted from prior literature on EDI and SCM (Iacovou, Benbasat, & Dexter, 1995; Otto & Kotzab, 2003; Ramamurthy & Premkumar, 1995). These items asked the respondents to rate the degree to which web applications in SCM resulted in improvements pertaining to customer service, cost reduction, inventory management, cycle-time reduction, supplier relationship management and generation of competitive advantage.

A list of measures we used in this study is provided in Table 3. Before conducting the survey, we pre-tested the survey instrument with six academic experts, and subsequently with eight senior IT executives. The survey instrument was iteratively refined based on the feedback obtained.

4. Data analysis

To analyze the data and examine the hypotheses, we used partial-least squares (PLS) approach, a second-generation technique in structural equation modeling. PLS follows a components-based strategy, makes no prior distributional assumptions about the data, and can work well with small sample sizes. PLS allows researchers to integrate and simultaneously assess both measurement and structural models. The measurement model investigates how well the latent constructs are captured by the mapped set of indicator items. The structural model estimates the strengths of hypothesized relationships among lateral constructs.

While the main focus of techniques like LISREL is to test a given model and examine the fit between the data and the model, PLS seeks to explain relationships within a model (Fornell & Bookstein, 1982). Therefore, PLS is more suitable for assessing predictive models where explaining relationships among a set of constructs is desired (Chin, 1998). Moreover, PLS allows modeling formative as well as reflective constructs. Formative constructs have indicators that form or cause the creation or change in the construct. In contrast, reflective constructs are those where the indicators reflect the same underlying concept (Chin, 1998). In our study, it was more appropriate to model formality as a formative construct, rather than as a reflective construct.

4.1. Reliability and validity: assessing the measurement model

Internal consistency is assessed by calculating internal composite reliability (CR) and average variance extracted (AVE) (Chin, 1998). Composite reliability is similar to Cronbach's alpha, and is calculated by squaring the sum of loadings then dividing it by the sum of squared loadings plus the sum of the error terms (Fornell & Larcker, 1981; Werts, Linn, & Joreskog, 1974). A value of 0.60 or more is considered adequate (Fornell & Larcker, 1981). The AVE measures the variance captured by the indicators relative to measurement error (Chin, 1998; Fornell & Larcker, 1981). Values reported in Table 3 exhibit adequate reliability for indicators of the constructs.

Discriminant and convergent validity tests check if measures of the constructs are distinct and if indicators load on the appropriate construct. To evaluate discriminant validity, the AVE need to be compared with the square of the correlations among the latent constructs (Chin, 1998). To exhibit adequate discriminant validity, the correlation among indicators of a construct should be greater than between a construct and any other construct. Another way to eval-

Table 3
Constructs and items.

Web-enabled SCM (CR = 0.961, AVE = 0.832)	
DI1	Extent to which web applications are used in:
DI2	Supplier selection (getting quotes, bids, etc.)
DI3	Purchase order processing
	Procurement from suppliers (distribution, warehouse, logistics, etc.)
DI4	Invoicing and payment processing
DI5	Demand Management (procurement analysis)
Performance impact (CR = 0.951, AVE = 0.763)	
	Perceived, realized benefits from web-technology:
PI1	Improved customer service
PI2	Better inventory control
PI3	Reduced operations costs
PI4	Reduced cycle time
PI5	Better relationship with suppliers
PI6	Generate competitive advantage
Supplier Synergy (CR = 0.904, AVE = 0.703)	
SS1	Importance of having continued business relationship with suppliers
SS2	Significant proportion of total profits related to profits from sale/service to suppliers
SS3	Dependence of suppliers on firm for achieving their business goals
SS4	Bargaining power of suppliers/partners
Information intensity (CR = 0.928, AVE = 0.813)	
II1	Products/services in industry generally require a lot of information to sell
II2	Products/services in industry are complicated or complex to understand /use
II3	Ordering of products/services is generally a complex process
Managerial IT knowledge (CR = 0.948, AVE = 0.821)	
MK1	Functional management's knowledge of the potential of web for future success of firm
MK2	Functional management's knowledge of potential of web in improving business processes
MK3	IT management's knowledge on business operations of the firm
MK4	IT management's knowledge on business strategies of the firm
Inter-operable IT infrastructure (CR = 0.919, AVE = 0.790)	
IO1	Compatibility of new web-SCM applications with existing data resources
IO2	Compatibility of new web-SCM applications with existing telecomm infrastructure
IO3	Compatibility of new web SCM applications with existing information systems
IT ROI (CR = 0.906, AVE = 0.763)	
	Costs in relation to the perceived benefits:
ROI1	Initial investments for hardware, software and application development
ROI2	Costs to train employees to effectively use the web SCM application
ROI3	Costs of integrating web SCM application with other information systems
Formal governance mechanisms ^a	
FGP	Formal plan for web SCM initiatives
FGT	Dedicated cross-functional team for carrying out the web SCM initiatives

^a Formative construct; each item was a 0–1 variable.

uate discriminant validity is to examine the factor loadings of each indicator on to the corresponding latent construct. Each indicator should load higher on the construct of interest than on any other variable. Before performing PLS analysis, we also conducted a factor analysis and examined the inter-construct correlations among our research constructs. Results presented in Tables 4 and 5 demonstrate adequate discriminant and convergent validity.

4.2. Testing hypotheses: assessing the structural model

PLS, being a statistical distribution free, nonparametric technique, requires a re-sampling procedure for significance tests to provide estimates of confidence intervals for path coefficients.

Table 4
Factor analysis results.

Construct	Items	Components						
		1	2	3	4	5	6	7
Supplier synergy	SS1	.247	.024	-.044	.751	.077	.179	.198
	SS2	-.015	.222	-.023	.809	-.024	.095	.079
	SS3	.143	.045	.111	.852	.096	.107	.067
	SS4	.148	.135	.063	.827	.092	-.010	-.057
Interoperable IT infrastructure	IO1	.025	.124	-.019	.130	-.074	.862	-.087
	IO2	.042	.094	-.042	.094	.075	.903	.017
	IO3	.140	.066	.011	.081	.051	.854	.061
Managerial IT knowledge	MK1	.122	.083	.900	.060	-.008	.032	.032
	MK2	.105	.062	.922	.051	.014	.030	-.010
	MK3	.036	.146	.892	.028	-.064	-.035	.107
	MK4	.011	.195	.853	-.025	-.036	-.081	.054
Perceived IT ROI	ROI1	.013	-.076	.036	.160	.009	.017	.868
	ROI2	-.009	-.050	.011	.014	.025	-.053	.885
	ROI3	.043	-.116	.117	.051	.084	.032	.822
Information intensity	II1	-.024	.226	-.032	.041	.882	-.006	.081
	II2	-.013	.185	.011	.053	.896	.039	.126
	II3	.092	-.005	-.068	.119	.883	.023	-.070
Web-enabled SCM	DI1	.277	.841	.047	.093	.122	.052	-.120
	DI2	.295	.855	.124	.166	.143	.101	-.089
	DI3	.281	.879	.098	.153	.079	.043	.018
	DI4	.288	.832	.185	.141	.072	.088	-.091
	DI5	.269	.743	.215	.008	.136	.147	-.100
Performance impact	PI1	.816	.199	.019	.171	.011	.152	.014
	PI2	.883	.244	.064	.075	-.024	.002	.046
	PI3	.854	.270	.034	.033	-.087	-.017	.028
	PI4	.845	.268	.050	.036	.084	-.027	.096
	PI5	.724	.346	.105	.261	.093	.108	.102
	PI6	.835	.096	.111	.118	.046	.119	-.189

Based on the recommendations of Efron and Tibshirani (1993) and Chin (1998), we used a bootstrapping approach to produce parameter coefficient estimates, standard errors and *t*-values. We generated 250 random samples of observations from original dataset, by sampling through replacement, where each sample's size was similar to those in original dataset. The path coefficients were re-estimated using each one of these samples. The resultant vector of parameter estimates was used to compute the parameter means and standard errors needed for computing the significance of the path coefficients.

The results of the PLS structural model analysis are provided in Fig. 2. The test of each hypothesis can be mapped to each specific path in the structural model. The estimated path coefficients, along with their significance levels, are provided. The R^2 is indicated next to each dependent construct in our model. All the hypothesized paths, from antecedents to the web-enablement of SCM activities, and the path between web-enabled SCM and performance impact were found to be significant ($p < 0.01$). The model provides support for all of our proposed hypotheses.

Our research model demonstrates reasonably good explanatory power for web-enabled SCM, with over 43% of variance explained ($R^2 = 0.43$). Further, our research model also accounts for 33% of variance in the performance impacts of web-enabled SCM activities. Of the proposed antecedents to the web-enabled SCM construct, the effect of formal governance mechanisms is more dominant, with a direct path coefficient of 0.38 significant at 1% level, as compared to other antecedents.

Our results also reveal that all the four sets of factors derived from Dyer and Singh's (1998) work on relational rents play a significant role in driving the web-enablement of SCM activities. Both supplier synergies and information intensity in supply chain environments seem to have more or less equal effect (positive and significant) on web-enablement of SCM activities. Technical considerations, as captured by inter-operability, though positive and significant in effecting web-enablement, has a relatively lower effect as compared to managerial IT knowledge, perceived returns on investments from IT, and formal mechanisms for executing web-enablement of SCM activities.

Table 5
Correlation matrix and average variance extracted.

	1	2	3	4	5	6	7	8	9
1. Supplier synergy	0.70								
2. Information intensity	-0.02	0.81							
3. Managerial IT knowledge	0.09	0.02	0.82						
4. Interoperable IT infrastructure	0.19 ⁺	-0.12	-0.00	0.79					
5. Perceived IT ROI	0.18 ⁺	0.14	0.13	0.00	0.76				
6. Formal governance – planning ^a	0.01	0.07	0.11	0.01	0.02	NA ^a			
7. Formal governance – team ^a	0.03	-0.03	0.18 ⁺	0.01	0.01	0.59 ^{**}	NA ^a		
8. Web-enabled SCM	0.28 ^{**}	0.19 ⁺	0.16 ⁺	0.16 ⁺	-0.18 ⁺	0.44 ^{**}	0.27 ^{**}	0.83	
9. Performance impact	0.36 ^{**}	0.03	0.15	0.17 ⁺	-0.14	0.29 ^{**}	0.16 ⁺	0.74 ^{**}	0.76

Bold numbers are AVEs.

^a Items from formative construct.

⁺ $p < 0.05$.

^{**} $p < 0.01$.

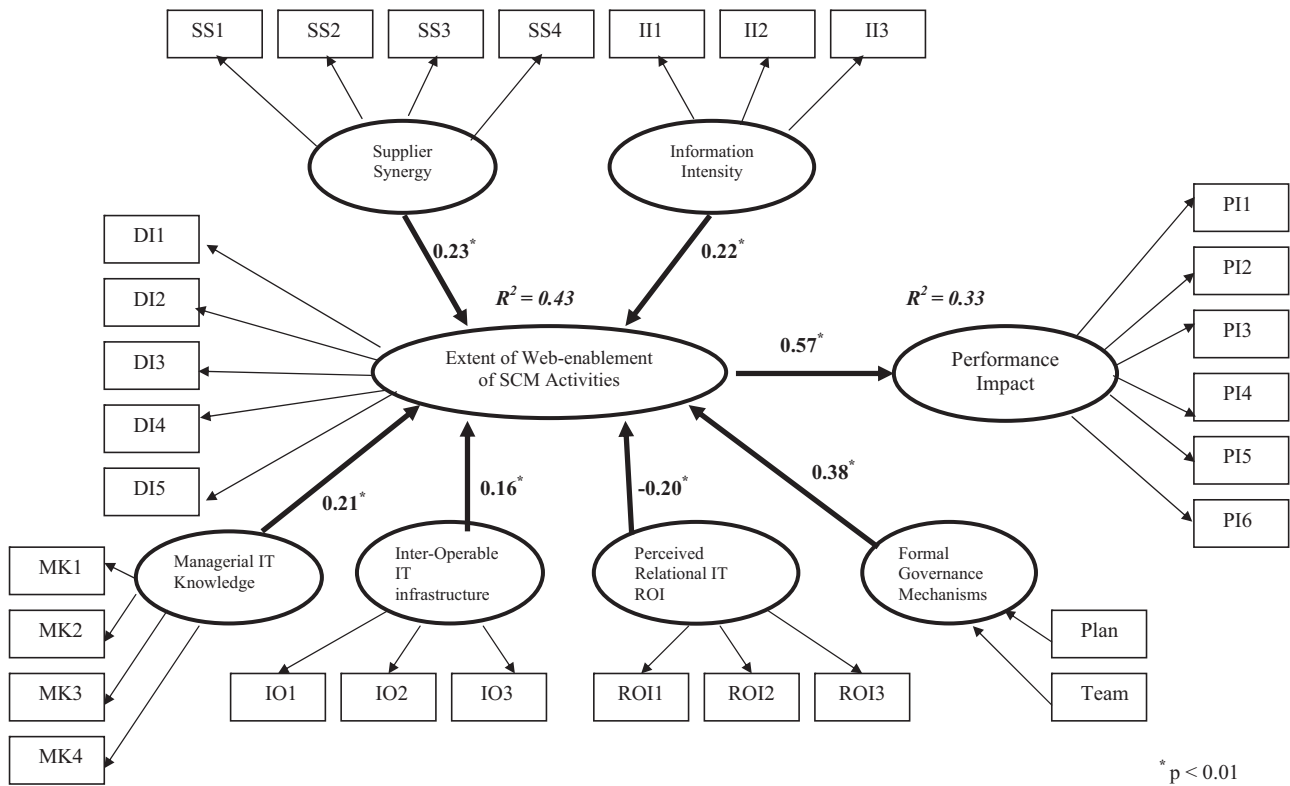


Fig. 2. Assessment of structural model: results.

5. Discussion and implications

There is growing evidence suggesting that practitioner managers are increasingly realizing that improving the practice of supply chain management to advanced levels is proving to be a difficult exercise. For example, an extensive industry survey by Poirier and Quinn (2003) found that the majority of companies “are still struggling to reach the more advanced stages of supply chain management in which collaboration and the use of digital commerce and other cyber-based communication techniques are applied with external partners.” Similarly, Sengupta (2004) suggests that while no one disputes the economic impact of supply chain management, “initiatives to improve supply chain processes have fallen short of expectations”. In this regard, use of web technologies is proving to be beneficial to enhance SCM activities in organizations (Frohlich, 2002). Findings of our investigation of key factors impacting the level of web-enabled SCM activities have significant implications for advancing both the practice of SCM as well as theoretical development.

In this paper, we build upon Dyer and Singh’s (1998) work on relational rents to understand the key factors affecting the web-enablement of SCM activities. We also drew upon a number of organizational theories namely resource-based view, knowledge-based theory of firm, information processing theory and structural perspectives to understand the associations between the key factors and the extent of web-enablement of SCM activities. Our study demonstrates the utility of using multiple organizational theories to explain web technology usage in supply chain management.

Web-enabling SCM activities is not a simple technology implementation exercise and our findings show a strong influence of supply chain environment and techno-organizational factors on the extent of web-enablement, and its ultimate impact on the benefits realized. Sengupta (2004) suggests that it is imperative that companies implementing SCM “not get caught up in the SAP project or the Manulogistics Project” on the assumption that information

technology is the sole enabler of SCM. Poirier and Quinn (2003) also conclude that companies too often spend resources on off-the-shelf packages expecting a “silver bullet” SCM solution and despite having invested in sophisticated software and technology, they are disappointed with the results of the SCM technology investments. As our results reveal, executives needs to pay attention to the IT-related enablers such as the inter-operability, IT-business partnerships and formality in their efforts in web-enabled SCM, in addition to paying attention to technology as well.

Our finding on supplier synergy and web-enabled SCM has several key implications for managers. First, it highlights the strategic and industry contexts in which supplier collaboration through web-enabled SCM can work effectively. It provides widely-based empirical support to various case-study based evidence that exemplifies how companies like Wal-Mart, Dell, and Proctor and Gamble are able move to advanced levels of SCM practice by exploiting strategic synergies with selected trading partners using leading-edge application of web technologies that provide online visibility and inter-enterprise collaboration. SCM managers in other sectors need to identify, nurture or develop such contexts that emphasize strong supplier synergies before proceeding with web-enabling SCM activities if they wish to replicate the successes of the likes of Wal-Mart, Intel and Dell. Such supplier synergies may also be more pertinent in some sectors than others. This could suggest that web-based SCM initiatives are more likely to succeed and can be expected to have a larger impact in some industry sectors and geographical areas (that offer scope for strong supplier interdependence) over others. For example, industry sectors that have a pre-existing tradition of supplier collaboration, trust, vertical integration investments, etc. have a natural advantage over others with a weaker collaborative tradition in supplier relationships. An implication for consultants and vendors of SCM applications is that rather than arguing for the universal application of SCM applications in all contexts they may want to adopt a more nuanced approach that focuses web-enabled SCM applications for contexts with strong

supply synergies. This finding may also explain why so many of the new start-up “dot-coms” of the internet era that tried to exploit supply chain intermediary business models failed while the more traditional players with longer managerial traditions of building supplier synergies are succeeding at web-enabling SCM activities at sophisticated levels. Building up a new synchronized supply chain is certainly a more difficult endeavor than web-enabling an established one with strong supplier synergies.

Another key implication of this finding is that web-enabled SCM applications must be couched in more broadly based managerial initiatives and tactics focusing on supplier relationship management. Just as managerial ideas about customer relationship management (CRM) have provided a strong base for CRM technology applications on the customer-interface side of organizational business processes, SCM applications must also be driven by stronger operational managerial paradigms about how to identify and develop strong supplier synergies. From a theoretical perspective, any movement towards a stronger theoretical foundation for supply chain management will have to include an explicit consideration of supplier relationships and the role that technology plays in amplifying, exploiting or weakening such supplier synergies.

Our study measured information intensity in relation to the informational complexity of the processes for ordering, selling and using a company's products and services. We found informational intensity to be a significant predictor of web-enabled SCM. This finding explains the experiences of Dell and Intel in web-enabled SCM activities given the informational complexities involved in the supply chain synchronization for their technical products and services. Informational complexity in the sub-processes of supply chains necessitates massive information flows both upstream and downstream of the chain providing more opportunities for supply chain reengineering. From an operational perspective, complex products and services (i.e., highly information-intensive) often require more supply chain coordination and synchronization because both the number of sub-components and the number of specialized suppliers are larger. Organizations with complex products and services will therefore be more motivated to undertake web-enablement of SCM activities as they perceive greater benefits from the leveraging effects of web technology on processes. The RosettaNet case study of supply chain reengineering in the computer industry (El Sawy, 2001) provides a good illustration of these possibilities by emphasizing how a unifying set of partner-interface processes (PIPS) and a generic specification for operational processes characterized as a sequence of “source-deliver-assemble” activities can serve as a powerful basis for understanding misalignments and collaboration opportunities in complex supply chains.

While the underlying logic and reasoning that explains this finding is well supported in the literature, there are also key implications for practitioners. Web-enablement of SCM initiatives may be more operationally viable in the case of complex products, services and processes than in contexts involving lesser levels of informational complexity. Web-enabled SCM initiatives should not just be planned with on a sub-optimal ambition basis that only targets “low-hanging-fruit” optimization successes. On the contrary, the greater need for cost-effective information sharing in information intensive environments and complex supply chains provide a strong basis for web-enabled SCM (Kearns & Lederer, 2003). Practitioners and vendors may also want to pay greater attention to the measurement and use of information intensity as part of supply chain reengineering methodologies.

Supply chain management has become popular in the last decade primarily because the underlying technologies for process integration; coordination of physical, information and financial flows; and inter-organizational synchronization; have become viable. However, the potential of the technologies can only be

realized through cross-functional planning, design and execution of reengineered business processes. This requires that IT executives and functional business process executives have to partner in these activities, thus augmenting the level of managerial IT knowledge. We had hypothesized a significant and positive association between managerial IT knowledge and web-enabled SCM, and found support for the same. This significant result suggests that web-enabled SCM is more likely to succeed in organizations with IT executives who are knowledgeable about the business processes and strategies of the organization as well as business process executives who are knowledgeable about the potential of web technologies to add value and contribute to both organizational business processes and the overall performance of the business. A key implication is that not only do IT and operational managers have to collaborate but mechanisms for growing cross-functional knowledge repositories and expertise are required for success. The literature on knowledge management and supply chain management (Corbett & Blackburn, 1999) suggests several managerial practices: (1) rotating operational managers into IT roles and IT managers into operational functional supply chain roles; (2) facilitating the knowledge management sub-processes of socialization, externalization, combination, and internalization among operational and IT managers; (3) setting up cross-functional SCM project teams; and (4) having the IT department play a direct role in business processes instead of a supportive staff function. It is also critical that organizations considering web-enabled SCM initiatives plan for and develop cross-functionality before such projects are launched, rather than view managerial cross-functionality as a given.

From a theory building perspective, prior studies have documented and recognized the critical roles that both IT executives and operational executives have to play in SCM projects. Our study adds to this knowledge by keying-in on the partnership and cross-functional knowledge sharing dimensions of these roles.

In our study, inter-operable IT infrastructure was measured in terms of the compatibility of web-based SCM applications with pre-existing databases, IT infrastructure and information system applications. Many large organizations often spent up to 70% of their IT budgets on the maintenance of legacy systems and infrastructure on which core transaction processing applications run and this can often exert a negative impact on the adoption of new technologies. We found that greater interoperability led to higher levels of web-enabled SCM. This finding supports the argument for a staged approach to SCM implementation with initial stages focusing on internal integration. Poirier and Quinn (2003) have argued that for SCM practice to reach more advanced levels of SCM such as value chain collaboration and full network connectivity, it is critical to go beyond the initial Enterprise Resource Planning (ERP) applications that (while being web-enabled) largely facilitate internal integration and which represent the primary category of IT applications being used for facilitating SCM today. Our findings which focus on web technology applications for supply chain management that facilitate digital commerce and internet-based collaboration with external partners represent this more advanced frontier for SCM. It is therefore important for organizations undertaking ERP implementation as a first step to a fuller SCM rollout, to ensure that their ERP systems are web enabled as this will facilitate later steps focusing on building network and application connectivity with other supply chain partners based on the TCP/IP protocol. Most ERP vendors recognize this significant interoperability issue today and have quickly built up Internet-enabled supply chain logistics modules to facilitate integration with the back-end systems of supply chain partners using a diverse set of legacy databases, IT infrastructure and applications. SAP's R/3 software is a good example of this as its initial versions were not Internet-enabled and did not include supply chain logistics functionality. The company quickly recog-

nized the significance of the inter-operability factor and made the necessary changes to its software.

Another implication of this finding is that supply chain reengineering methodologies must focus on mechanisms for enhancing compatibilities during the initial planning processes, e.g. the focus on structured partner-interface-processes (PIPS) in the RosettaNet case (El Sawy, 2001). It must be recognized that the challenge of over-coming inter-operability is certainly greater in the case of supply chain reengineering involving multiple supply chain partners than was the case for first generation business process reengineering of internal business processes. In view of the fact that operations management has a long tradition of distinguishing between planning processes and operational processes, it is also critical to recognize that inter-operability must be considered in both these sets of processes.

Our study found a significant inverse relationship between perceived costs relative to the benefits and the level of web-enabled SCM. We measured perceived IT ROI in terms of respondent's perceptions about the costs and investments required for web-enabled SCM including costs of hardware, software, training and systems integration in relation to perceived benefits. Higher levels of perceived cost/investments as compared to expected benefits reduce the level of web-enablement of SCM activities and vice versa. Given that all these categories of costs of web-enabled SCM have come down significantly in line with the recent downturn in the IT industry, our finding implies that this may accelerate the pace and levels of web-enablement of SCM activities. Small and medium size organizations may also find that web-enabled SCM is now a more viable option for them.

However, the relationship between perceived IT ROI and the level of web-enabled SCM may not be linear and there is a need to understand the confounding influence of the level of SCM sophistication especially since Poirier and Quinn (2003) and Sengupta (2004) have found that many SCM initiatives in industry remain stagnated at the lower levels of SCM evolution. Perceived IT ROI may be higher at the initial stages of SCM implementation that largely involves basic web-enablement and automation of essential communication capabilities than at later SCM stages where more sophisticated and costly technologies (such as business intelligence and collaborative planning, forecasting and replenishment – CPFR) for supply chain optimization are required and the realization of benefits represents a more risky proposition. Given that we did not directly measure the sophistication of SCM implementation, this should be the focus of future research. From a theoretical perspective, such future work may want to investigate the applicability of phenomenon such as the productivity paradox and theoretical constructs such as relative advantage that was the basis of our measures to the evolution and sophistication of SCM implementations.

Our study found a strong relationship between the use of formal governance mechanisms and dedicated structures and the level of web-enabled SCM that is achieved. It is imperative that organizations consider systematic and coordinated approaches for web-enabled SCM projects. Interestingly but unlike the situation for first-generation business process reengineering in the early 1990s where there were multitudes of formal methodologies, techniques and tools, both the practitioner and research literature on SCM is devoid of such formal methodologies for planning and carrying out supply chain web-enablement and redesign. The only exception that could be isolated was El Sawy (2001). This represents an opportunity for both researchers, who may want to focus on developing formal and dedicated methodologies and tools, and for SCM consultants and vendors, who are trying to add value to their clients, as it is obvious that informal ad hoc approaches are ineffective.

Organizations must ensure that dedicated teams, methodologies and resources for planning and implementing SCM initiatives

are likely to have a significant impact on the success of their web-enabled SCM projects. Growing evidence of a situation where the vast majority of firms are struggling to reach the advanced stages of SCM implementation and are largely dissatisfied with the pay-offs, may be addressed by adopting more formal web readiness approaches and operational process implementation methodologies. This logic is in line with prior studies in other related areas and there is increasing research interest in organizational design features for supply chain management (Trent, 2004). Similarly, Pagell (2004) identifies the amount of formal and informal communication across supply chain functions as a key factor impacting integration in operations, purchasing and logistics. Formalization and structuring of SCM initiatives can be expected to help overcome both the supply chain innovation and process implementation challenges of web-enabled SCM thereby ensuring their success.

Our research model also included investigation of the impact of web-enabled SCM on realized gains in performance and this was found to be significant. The greater the extent to which web technologies are used in supply chain processes such as supplier selection, order processing, logistics, invoicing, demand management, etc. the greater are the perceived realized benefits in relation to improved customer service, better inventory control, reduced cycle time, greater competitive advantage, etc. This finding validates those of several other recent research projects (Frohlich & Westbrook, 2002; Zhu & Kraemer, 2002). The industry survey by Poirier and Quinn (2003) concluded that there were modest to significant impacts in terms of cost reduction but not in terms of revenue generation. This suggests that web-enabled SCM projects are driven primarily by a cost-reduction approach to bottom-line improvement rather than a strategic attempt to boost gross revenues by leveraging the supply chain, such as in the case of Dell and Wal-Mart.

While we have relied on perceptual measurements given our sample size, research methodology and the diverse set of SCM projects in industry, future research may want to model specifically the direct financial measurements of improved organizational and supply chain process performance. Given the inter-organizational nature of supply chains, this is a non-trivial but critical direction for future research. Follow-up discussions with practitioners suggest that, given the popularity of web-enabled SCM initiatives, they do not doubt the significant positive impacts. However, they communicate a need for more direct measures for the purposes of project justification, designing cost allocation and benefit-sharing mechanisms in supply chain contractual negotiations, and SCM project evaluations. Poirier and Quinn (2003) also found that SCM executives rated the need for more accurate and structured methods of developing a business case for supply chain investments as the most critical area needing improvement. Such measurement of benefits should prove much easier than in the past given that web-enabled supply chain management represents a fundamental shift in that we are replacing our traditional reliance on inexact forecasting up and down a supply chain with collaboration based on the connectivity fostered by web-based SCM applications. Connectivity based on web-enablement will most definitely provide us with more precise and reliable measures for employing a more scientific "measure and manage" modeling basis for SCM.

6. Limitations and conclusions

Despite some interesting findings and implications, our study has several important limitations as well. First, we used perceptual measures for assessing the performance impacts and future researchers could try and use more objective measures for capturing the web-enabled SCM benefits in financial terms. Second, we used single respondent from each target firm, thereby raising

the issue of common method bias. To address this problem, we conducted Harmon's one-factor test for common method bias. The underlying logic in this test is that if all measured variables were biased by a common method, then all variables should load up on a single factor in an exploratory factor analysis or one factor would account for most of the observed variance (Podsakoff & Organ, 1986). Exploratory factor analysis conducted on all of our measured items revealed no single factor account for most of the variance, thereby indicating that common method bias is not likely to be significant. Third, our study focused on selected factors inspired from research on relational rents. There could be several other factors such as the supply chain structure, complexity of processes, etc. that could potentially influence web-enablement of SCM activities.

In conclusion, this study investigated the dynamics underlying the web-enablement of supply chain management activities, examined the key factors that potentially influence the extent of web-enabled SCM, and documented the performance impacts of web-enabled SCM. Our results revealed a strong positive influence of supplier synergy, information intensity in supply chain environment, managerial IT knowledge, inter-operability and formal governance mechanisms on the degree of web-enablement of SCM activities. We also found a negative association between relative cost-benefit perceptions and the extent of web-enabled SCM. Further, we also found strong positive association between extent of web-enabled SCM and the benefits realized from web-enabled SCM efforts. Given the growing research in this area, we hope our study helps in increasing the basic understanding of web-enabled SCM from a relational rents perspective, thereby paving the way for advancing knowledge in this area.

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